602
new 82-10

ontario hydro
research division
COMPLIMENTARY COPY
Please Credit Ontario Hydro Research if
Reproduced in Whole or in Part

PICKERING NGS 1990 VACUUM BUILDING OUTAGE - INSPECTION OF VACUUM BUILDING ROOF SEAL REPLACEMENT

Report No. 90-196-K

R.J. Lewak
Engineer
Materials Chemistry Section
Chemical Research Department

Abstract

This report describes the replacement of the Pickering NGS Vacuum Building roof seal performed during the May 1990 vacuum building outage. During the replacement the Chemical Research Department performed inspections of the replacement procedure and the embedded parts to which the seal was mounted and made initial baseline hardness measurements of the new roof seal. The entire procedure was videotaped for future reference and key tasks during the installation were photographed.

job	file	date	report no.
32-143-553	833.4	September 4, 1990	90-196-K

01602
new 82-10

91-03162/

ontario hydro
research division

EXECUTIVE SUMMARY

PICKERING NGS 1990 VACUUM BUILDING OUTAGE - INSPECTION OF VACUUM BUILDING ROOF SEAL REPLACEMENT

R.J. Lewak

During the Pickering NGS May 1990 vacuum building outage the vacuum building roof seal was replaced. This replacement was inspected by the Chemical Research Department which included baseline durometer hardness measurements of the new seal and the videotaping and photography of all aspects of seal replacement including the entire length of the completed seal mounted in position.

The inspection included the inspection of the old polyester fabric reinforced neoprene rubber roof seal in position, its removal and shipment to Research Division, the inspection of the backup plates and embedded parts of the roof seal mounting fixtures and their subsequent refurbishing during the outage.

With regard to the new seal made of polyester fabric reinforced silicone rubber, every inch of the new seal surface was inspected. There were a few surface defects such as minor cuts and blisters. In addition a few small wire pieces from wire brushes used to clean the embedded parts had become embedded in the new seal. These were removed and the new seal cleaned before installation. The splicing procedure was observed and documented for both the test splice and the actual splice.

Once the seal was completely installed, hardness measurements were taken at the eight compass points. The hardness values were within specified limits. In addition, the compression of the seal under the backup plates was measured as well as the midpoint deflection both in an atmospheric pressure and vacuum condition of the vacuum building.

job	file	date	report no.
32-143-553	833.4	September 4, 1990	90-196-K

TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
2.0	INSPECTION OF OLD VACUUM BUILDING ROOF SEAL	1
3.0	INSPECTION OF BACKUP PLATES AND EMBEDDED PARTS	2
4.0	INSPECTION OF NEW VACUUM BUILDING ROOF SEAL	2
	4.1 Initial Visual Inspection	2
	4.2 Roof Seal Mounting	3
	4.3 Roof Seal Splicing	3
	4.3.1 Test Splice	4
	4.3.2 Final Roof Seal Splicing	4
	4.4 Final Roof Seal Mounting	6
	4.5 Baseline Measurements on Roof Seal	7
	4.6 Test Coupons	8
	4.7 Video Recording	8
5.0	CONCLUSIONS AND RECOMMENDATIONS	9
6.0	ACKNOWLEDGEMENT	10
7.0	REFERENCES	11

ontario hydro
research division

To: Mr. P. Charlebois
Technical Manager
Pickering NGS

PICKERING NGS 1990 VACUUM BUILDING OUTAGE - INSPECTION OF VACUUM BUILDING ROOF SEAL REPLACEMENT

R.J. Lewak

1.0 INTRODUCTION

During the Pickering NGS May 1990 vacuum building outage the vacuum building roof seal was replaced. During the outage it was the responsibility of the Chemical Research Department to perform inspections and to take initial baseline measurements of the new roof seal and the embedded parts to which the seal is mounted. In addition it was the responsibility of the Chemical Research Department to record the installation of the new roof seal in order that this installation procedure may be reviewed in the future when questions of roof seal replacement again arise.

2.0 INSPECTION OF OLD VACUUM BUILDING ROOF SEAL

The vacuum building (VB) roof seal is a fabric reinforced moulded elastomeric seal between the VB roof and the walls. Figure 1 shows a drawing of the cross-section of the VB roof seal and its relationship to the VB roof and walls. The old original roof seal, which had been in operation for 20 years, was made of polyester reinforced neoprene rubber. Previous inspection of this roof seal /1,2,3/ revealed that cracks had developed in the seal surface. These cracks had been repaired with a Hypalon coating/4/ and room temperature vulcanized (RTV) rubber had also been applied.

The old seal was inspected while it was still mounted to the embedded parts. There were no significant conditions thought worthwhile for recording. The compass points (N,S,E,W,NE,NW,SE,SW) were marked on the seal at this time. The seal was then removed, cut into 3 meter long sections which were marked as to position, and removed from the roof to the ground level from where they were transported to Research Division.

Figure 2 shows one of these old roof seal sections. The grey on the seal surface is the Hypalon coating on the exposed surface of the seal.

3.0 INSPECTION OF BACKUP PLATES AND EMBEDDED PARTS

Following the removal of the old VB roof seal, the now exposed embedded parts (EP's) and the inside surfaces of the backup plates were inspected for corrosion and surface quality. At this time any repairs which were required for either the backup plates or the embedded parts were performed. It was recommended to Pickering Operations that corrosion was to be removed with wire brushes or, failing that technique, by grinding, and all the surfaces of the embedded parts and the backup plates were to be recoated with a zinc epoxy coating (GLIDZINC 100). Slight surface corrosion was found on all embedded parts and backup plates, and example of which is shown on the embedded part in Figure 3. The recoating of a few of the backup plates is shown in Figure 4. The completed recoated EP's are shown in Figure 5 and 6.

4.0 INSPECTION OF NEW VACUUM BUILDING ROOF SEAL

4.1 Initial Visual Inspection

The new VB roof seal was made from a continuous length of polyester fabric reinforced moulded silicone rubber by Freudenberg NOK of Tillsonburg, Ontario. The seal was manufactured in 1985 at which time it was delivered to Pickering NGS where it was kept in storage. The seal was stored on a large spool which was lifted in its entirety to the VB roof as shown in Figure 7. A section of the seal showing the inner surface unwound from the spool is shown in Figure 8. The seal has a concave outer surface and a convex inner surface but is flat on both surfaces at the position of clamping. The holes of the seal have been pre-drilled and the hole inner surface sealed. There is only one splice in the seal and that is a field splice made after most of the seal has been mounted.

A portion of the length of the seal was unrolled and lay on the surface of the vacuum building roof. This section of the seal was the first to be examined visually. As the rest of the length of the seal was then unrolled from the spool it was examined visually on both surfaces. The great majority of the length of the seal was free from defects, however a few small defects were found along the seal length at discrete and random positions. It should be noted that none of these defects would lead to failure of the seal. Firstly, it appeared as if some of the holes were of poor quality as shown in Figure 9. As Figures 10 and 11 show, there were some small cuts on the flat sections as if the holes were to be made in other positions. Figure 12 shows a depression

around a hole. In some places there were blisters on the seal surface as shown in Figures 13 and 14. In some places there were small cuts and cracks as seen in Figures 15, 16, and 17. Lastly, it was found that occasionally around the length of the seal there would be embedded small lengths of wire as shown in Figures 18, 19, and 20. These lengths of wire had fallen from the wire brushes which had been used to clean the corrosion from the embedded parts and backup plates. As the seal was unwound from the spool it was merely laid on the roof surface which was not cleaned of debris such as wire scraps. It was suggested that instead of just laying the seal on the roof's surface, the seal should be supported by two by fours and have the seal cover beneath. This was done as shown in Figure 21.

4.2 Roof Seal Mounting

Before the roof seal could be mounted in position it was determined that according to where the ends of the seal were positioned, in the Northwest quadrant, there was not sufficient room for the equipment needed for making the splice of the ends. Consequently, the ends of the seal were shifted to the southern quadrant where sufficient room was available. This procedure is shown in Figures 22 to 26.

The seal was now in the correct position and ready for mounting onto the embedded parts. Prior to mounting each section was cleaned as shown in Figures 27 and 28. The seal was mounted in sections by first aligning each hole in the seal with its bolt hole as seen in Figure 29. Next a few bolts were fastened to hold the seal up and the process of fitting on the backup plates was performed as seen in Figures 30 to 33. The seal was left in this condition with the bolts on loosely until the splice was made.

4.3 Roof Seal Splicing

The splice in the roof seal was made by Mr. Bob Hagarty, an employee of Freudenberg NOK, the manufacturer of the VB roof seal. Once the seal had been moved so the splice location would be in a acceptable working location, measurements were made by Mr. Hagarty as to the lengths of material required for the splice so that the seal would exactly fit the circumference of the Vacuum Building roof and exactly fit onto the embedded parts. The roof seal had an extra length of approximately 20 meters. This extra length was cut from the roof seal and sent into storage at Pickering NGS. From this extra length, however, a one meter length of roof seal was cut for use in making a test splice. Since there is only one opportunity to make the splice, a test splice is required to test the splice making procedure.

4.3.1 Test Splice

Video recording was made of the entire test splice procedure. Unfortunately, due to equipment malfunction, the video portion of this recording is not usable. A photographic record of the final splice procedure is, however, available. The test splice was made with some difficulty as problems arose with bringing the seal mould press up to the correct temperature of 160 ^{o}C (320 ^{o}F) due to a cold wind cooling off the press. It should be mentioned that the splicing was performed out of doors. For the final splice a small hut was built on the roof to shield the press from the wind. The test splice was examined for both dimensional accuracy and Shore A durometer hardness by Chemical Research. On the test splice the durometer hardness readings were:

Outside Surface:	
Edge (near holes):	62, 62, 55, 55
Midpoint:	60, 60, 60
Inside Surface:	
Edge (near holes):	60, 60, 56, 60
Midpoint:	54, 56, 54

It should be pointed out that due to seal curvature, it is difficult to get accurate hardness readings on the inside surface midpoint. This accounts for the lower readings. These hardness readings and the test splice dimensional accuracy were acceptable so that approval was given to proceed with the final roof seal splice. The test splice was removed to Research Division for destructive examination and testing. Figure 34 shows an edge view of the test splice while Figure 35 shows the inside surface and Figure 36 shows the outside surface.

4.3.2 Final Roof Seal Splicing

The splice is a 12.7 cm (5 in) overlap splice so the seal was cut 25.4 cm (10 in) longer than the circumference required. To prepare the seal for splicing the following procedure was followed:

1. From both ends of the seal a length of 6.35 cm (2.5 in) was cut from the center of the hole so that a fresh surface is available on either end as shown in Figure 37.

2. From the edge of the first hole after the cut at a distance of 5.3 cm (2.1 in) a line was drawn. This line was 12.7 cm (5 in) from the end of the seal as shown in Figure 37 and was drawn on both sides of the seal.

3. One end of the splice will have the cover rubber removed from the outside surface and one end will have the rubber removed from the inside surface. Considering the outside

(concave) surface first and using a dull knife so as not to cut the reinforcing fabric, a transverse cut was made along the line inscribed in step 2 down to the fabric.

4. A 0.32 cm (1/8 in) taper was then cut back from the marked line in step 3 and shown in Figure 38.

5. Parallel transverse cuts were then made down to the fabric separated by 1.27 cm (1/2 in) and these strips of rubber were peeled off by cutting horizontally in the longitudinal and transverse directions as shown in Figure 38.

6. The seal was then turned over and the edge tapered back 1.27 cm (1/2 in).

7. Considering the inside (convex) surface, a transverse cut was made along the line inscribed in step 2 down to the fabric.

8. A 1.27 cm (1/2 in) taper was then cut back from the marked line in step 3 as shown in Figure 39.

9. The thick rubber edges were then cut off longitudinally as shown in Figure 39.

10. Parallel transverse cuts were then made down to the fabric separated by 1.27 cm (1/2 in) and these strips of rubber were peeled off by cutting as shown in Figure 39.

11. The seal was turned over and the edge tapered back 0.32 cm (1/8 in).

12. The tapered edges on both ends of the seal were then buffed using an emery cloth.

Once the seal ends were prepared for splicing the procedure was as follows:

1. All areas of the splice were cleaned first with acetone. Any loose rubber was removed.

2. Starting first with the end with the outside surface, a 0.127 cm (0.05 in) thick sheet of uncured AR290C(5) Rev.1 silicone rubber was placed over the exposed fabric and the other end of the splice placed over top of the uncured rubber as to fit the seal together as in Figure 40.

3. Then the 0.64 cm (1/4 in) gap at the edge of the splice was filled in with uncured rubber and knifed smooth as shown in Figure 41.

4. Silicone rubber plugs were then inserted into the holes of the seal which will be in the press to prevent hole distortion as shown in Figure 42.

5. The mould half corresponding to the outside surface was placed over the splice and the seal turned over to show the inside surface as in Figure 43.

6. The mould and seal was then put into the press as shown in Figure 44 with the ends of the seal clamped with boards to prevent any relative motion.

7. Using strips of uncured AR290C(5) Rev.1 silicone rubber, the gap was filled in as shown in Figures 45 to 54.

8. The top half of the mould was then set on the seal as shown in Figure 55 and then the top half of the press fitted on the mould as seen in Figure 56. All four corner nuts of the press were snugged up tight as seen in Figure 57.

9. At this time a small hut was constructed around the press to shield it from the cold wind.

10. The pressure in the press was set at 544 kPa (80 psig) and the temperature set at 160 ^{o}C (320 ^{o}F).

11. It took several hours for the press to reach 160 ^{o}C. The seal during this time period is shown from each side of the press in Figures 58 and 59. The seal was kept at 160 ^{o}C for a time of one hour.

12. Following the one hour curing time the heating elements of the press were disengaged and the pressure released. The shelter hut was removed and the nuts of the press removed as shown in Figure 60. The top of the press removed and the top half the mould removed.

13. The inside surface of the splice is shown in Figure 61, still in the mould. The flashings of rubber along the edges were removed with a knife. The seal was removed from the press and the dimensions and hardness of the splice checked.

Photographs of the splice are seen in Figures 62 to 64 showing the edges and the outside surface of the seal. The splice was completely satisfactory.

4.4 Final Roof Seal Mounting

Following the splicing procedure, the unmounted portion of the roof seal including the splice was mounted in a fashion described previously. The final task of the mounting procedure was to tighten all the bolts to torque of 78 N-m (60 ft-lb). An

untightened and a tightened section of the seal are shown together in Figure 65. This procedure had to be performed a number of times due to stress relaxation of the seal.

4.5 Baseline Measurements on Roof Seal

Baseline measurements were made at eight compass points and splice for seal Shore A hardness, seal deflection at the midpoint between the clamped sides of the seal before and after vacuum building evacuation, and thickness of embedded part plus seal plus backup plate. Before VB evacuation the measurements were as follows:

Position	Hardness	Deflection(mm)	Thickness(mm)	
			Top	Bottom
Splice Left Right	60,60,60,61 64,62,62 64,63,63	49	60	60
South	64,66,66,64	46	60	60
SW	63,62,60,60	48	60	59
West	63,58,59,63	49	59.5	57
NW	65,65,63	47	57	57
North	66,67,66,64	46	58	57.5
NE	65,65,60,64	48	60	60
East	64,64,65,64	49	61	60
SE	63,65,66,62	47	59	59

It should be noted that the hardness measurements cannot be measured according to ASTM 2240-86 for the simple reason that once the seal is mounted in place the dimensional qualifications of this test cannot be met and a hard horizontal surface as prescribed cannot be found. To the extent that the hardness tester is calibrated, this test is accurate, but these measurements can only be used for comparison with measurements on the same seal at the same positions later in time. To find a hard surface beneath the seal, measurements were taken close to the backup plates.

When the vacuum building was evacuated, measurements of seal deflection and thickness were taken:

Position	Deflection(mm)	Thickness(mm)	
		Top	Bottom
North	52.5	58	57.5
NE	55	59	59
East	60.5	61	60
SE	55	58	58
South	55	59.5	58
SW	57	59	59
West	53.5	59.5	57
NW	51	58	55

During the evacuation, a small leak between the seal and the backup plate was found and corrected at a point in the southwest quadrant by tightening the bolts at that position. This position was marked with an L on the seal.

4.6 Test Coupons

Two test coupons of the roof seal, approximately 70 cm long, were made from the extra length of roof seal and bolted with clamps in a similar manner to the actual roof seal as shown in Figures 66 and 67. This was done so that material for any future tests to be performed on roof seal material aged under similar conditions would be available. To simulate the condition of the outside surface of the roof seal the coupon shown in Figure 66 was attached to the roof in a vertical orientation underneath the roof seal covers near the roof seal splice in the southern quadrant. Initial Shore A hardness readings of this coupon were: 60,60,60. The second coupon, in Figure 67, had similar hardness readings, and, to simulate the conditions on the inside surface was installed inside the emergency storage water tank on the top east-west beam near the west roof hatch.

4.7 Video Recording

The entire procedure of the Vacuum Building roof seal replacement has been recorded on videotape. In addition, once the new roof seal had been installed and the vacuum building evacuated, the

entire circumference of the roof seal was imaged on videotape. These videotapes are kept on file by the Materials Chemistry Section of the Chemical Research Department.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The entire vacuum building roof seal replacement was performed in a highly professional manner. If and when this exercise is to be repeated though, there are a number procedural steps which could be revised. The first is that there should be better communication between the installers of the seal and the person making the splice as to the space required for the splicemaking. This would prevent having to move the ends of the seal to a new location as in this installation. Second, more care should be given by the installers to the new seal. This would prevent the seal from picking up any debris such as small wires.

In terms of the measured values of hardness, it is concluded that the values are within the acceptable range of hardness for adequate seal operation.

It is recommended that hardness measurements be made at the same compass points and at the splice of the roof seal biennially. If the measurements are within the expected range, the seal is operating satisfactorily, and damage to the seal is not extensive over the decade between vacuum building outages, the test coupons need not be removed and tested prior to the 2000 vacuum building outage.

6.0 ACKNOWLEDGEMENT

The author would like to acknowledge the assistance of Mr. C. Breckenridge and Mr. D. Mueller who performed much of the photography and videotaping as well as taking measurements for this project. The author would also like to acknowledge Mr. B. Hagarty of Freudenberg NOK for giving him the splicing procedure.

Approved by:

D.J.R. Dodd
Manager
Chemical Research Department

Prepared by:

R.J. Lewak
Chemist
Materials Chemistry Section

Reviewed by:

R.W. Glass
Supervising Chemist
Materials Chemistry Section

7.0 REFERENCES

1. Cordingley, D.C., "Examination of Vacuum Building Roof Seal Pickering NGS 'A'", CHRD Report No 79-328-K, August 20, 1979.

2. Cordingley, D.C. and Fayle, G.W., "Vacuum Building Roof Seal Inspection (Pickering NGS)", CHRD Report No 84-417-K, March 25, 1985.

3. Fayle, G.W., "Vacuum Building Roof Seal Inspection - Pickering NGS", CHRD Report C87-90-K, Oct. 14, 1987.

4. Winn, R.W., "Vacuum Building Roof Seal Inspection and Repair - Pickering NGS", CHRD Report C88-114-K, December 13, 1988.

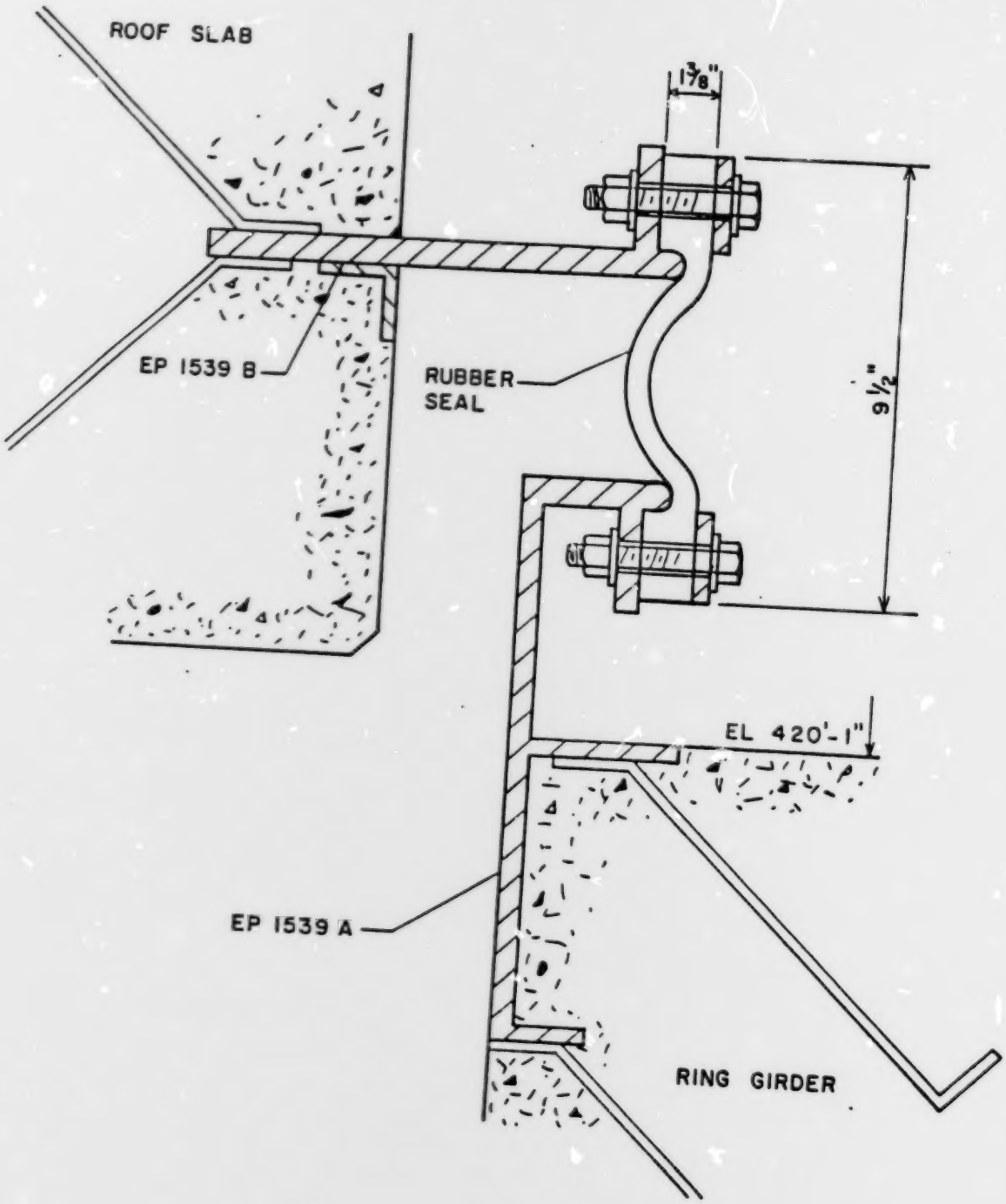

Figure 1

Cross Section of Vacuum Building Roof Seal

FIGURE 2

Old Polyester Reinforced Neoprene Rubber Roof Seal Section

FIGURE 3

Corrosion of Embedded Parts

FIGURE 4

Recoating of Backup Plates

FIGURE 5

Recoated Embedded Parts

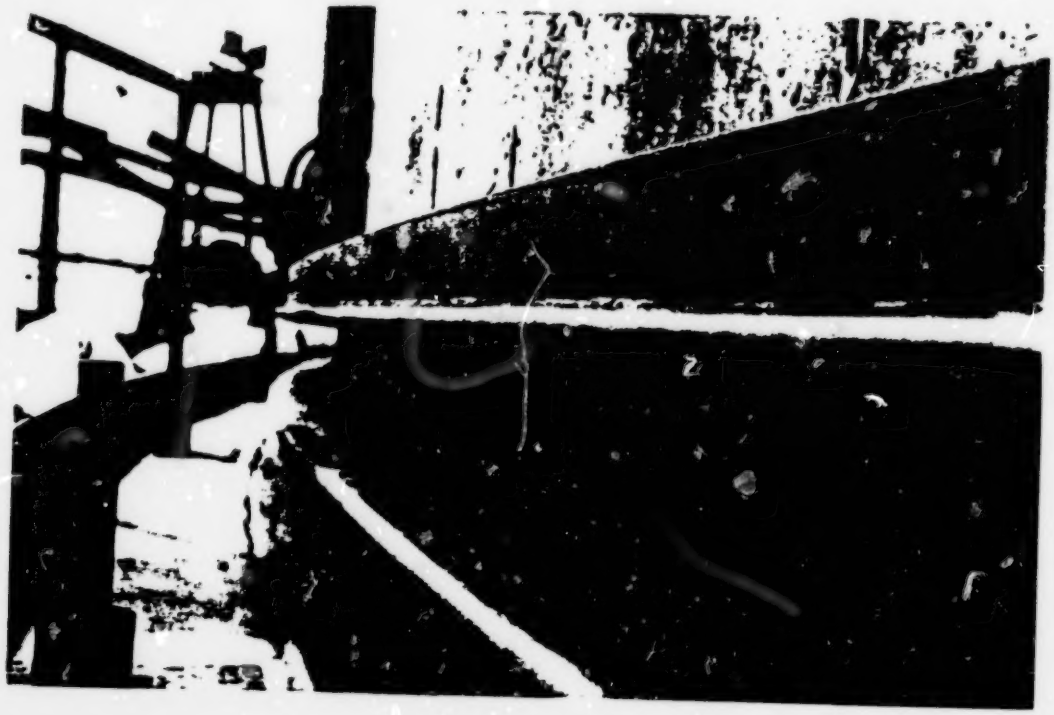

FIGURE 6

Recoated Embedded Parts

FIGURE 7

New Roof Seal Stored on Spool

FIGURE 8

New Roof Seal - Inside Surface

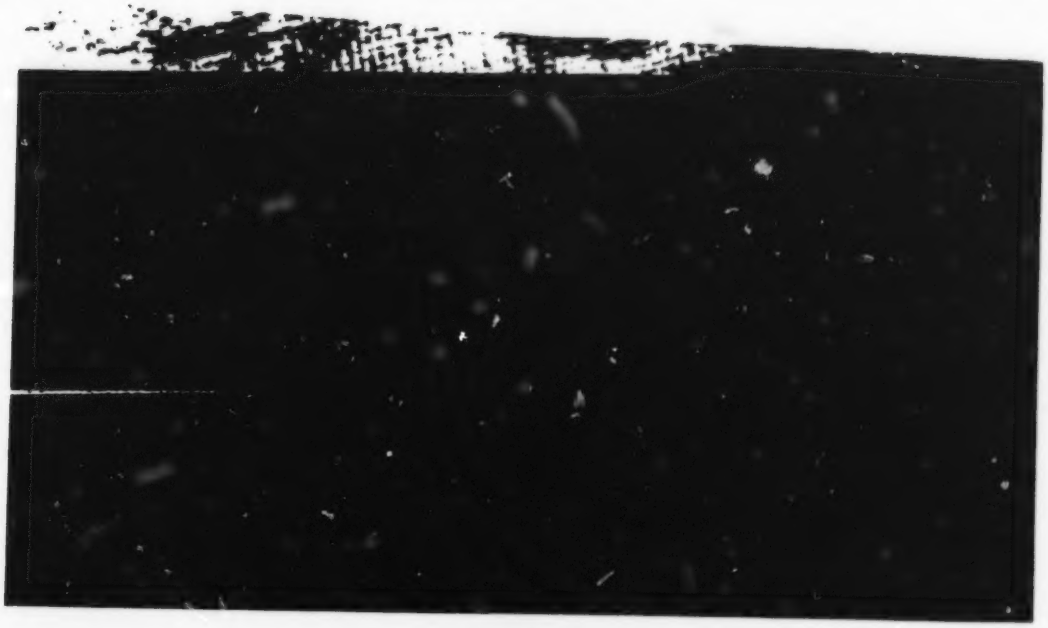

FIGURE 9

Poor Quality Hole in New Roof Seal

FIGURE 10

Small Cuts Next to Holes on New Seal

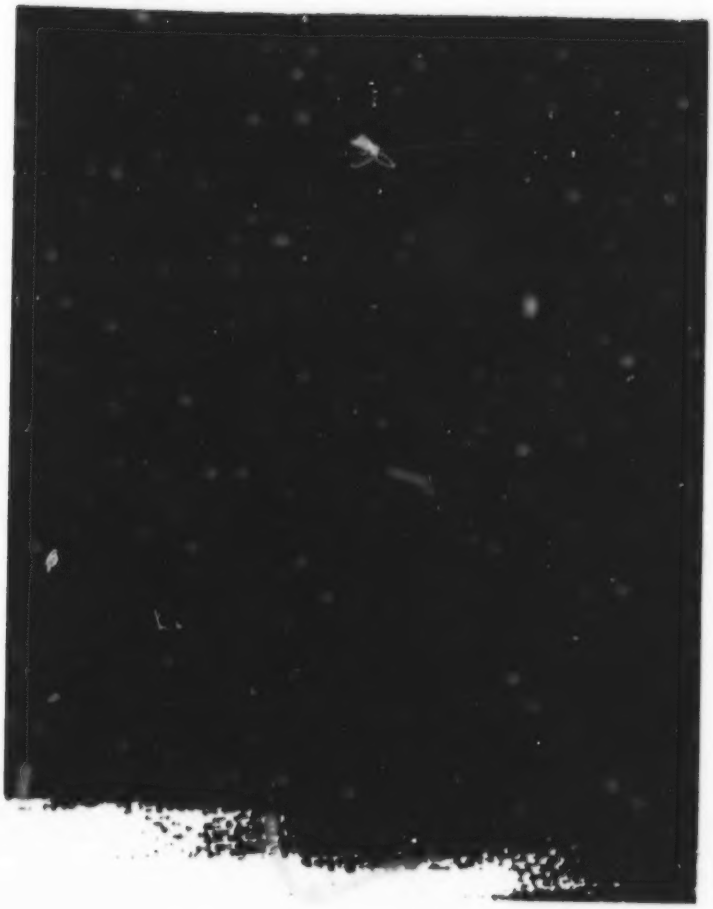

FIGURE 11

Small Cuts Next to Hole on New Seal

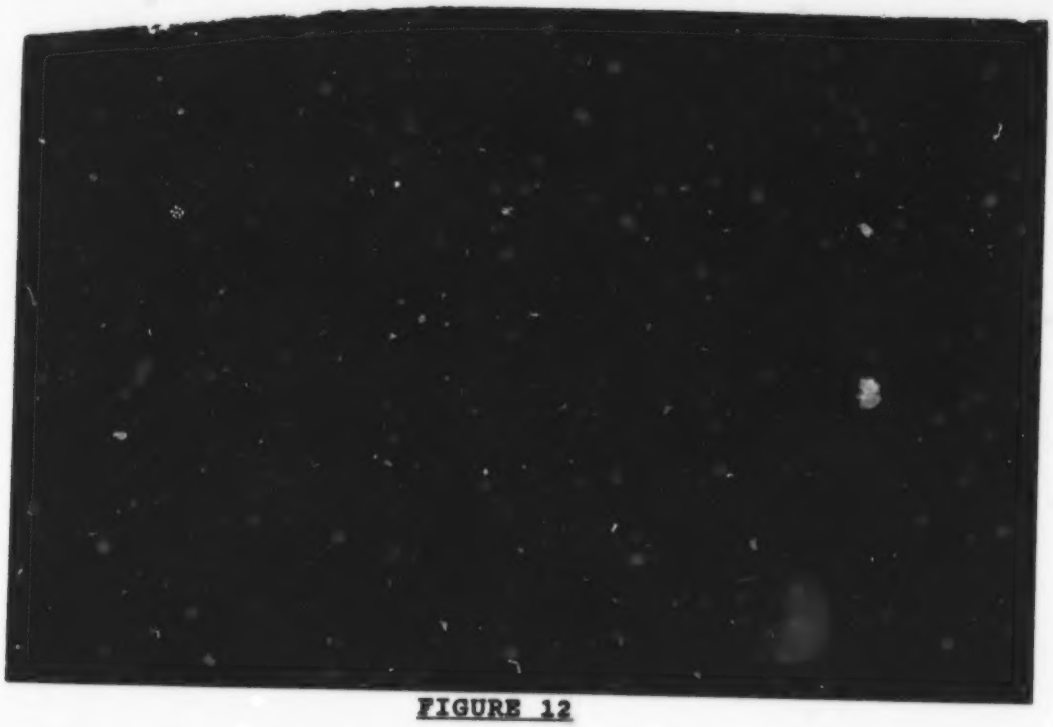

FIGURE 12

Depression Around Hole in New Seal

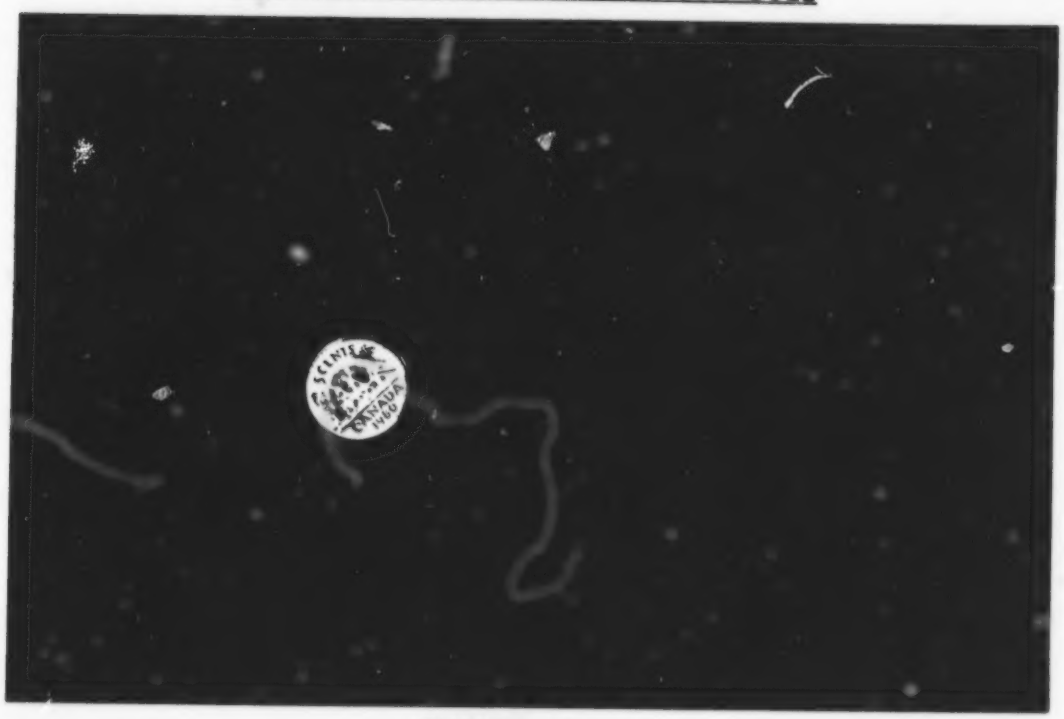

FIGURE 13

Blister on New Seal Surface

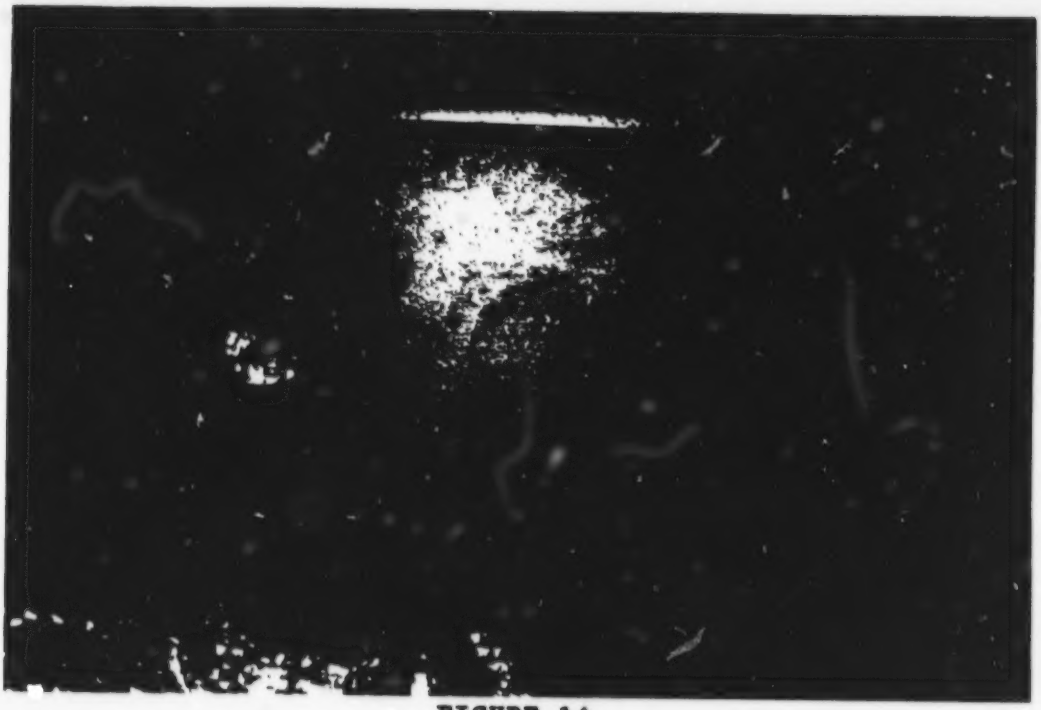

FIGURE 14

Blister on New Seal Surface

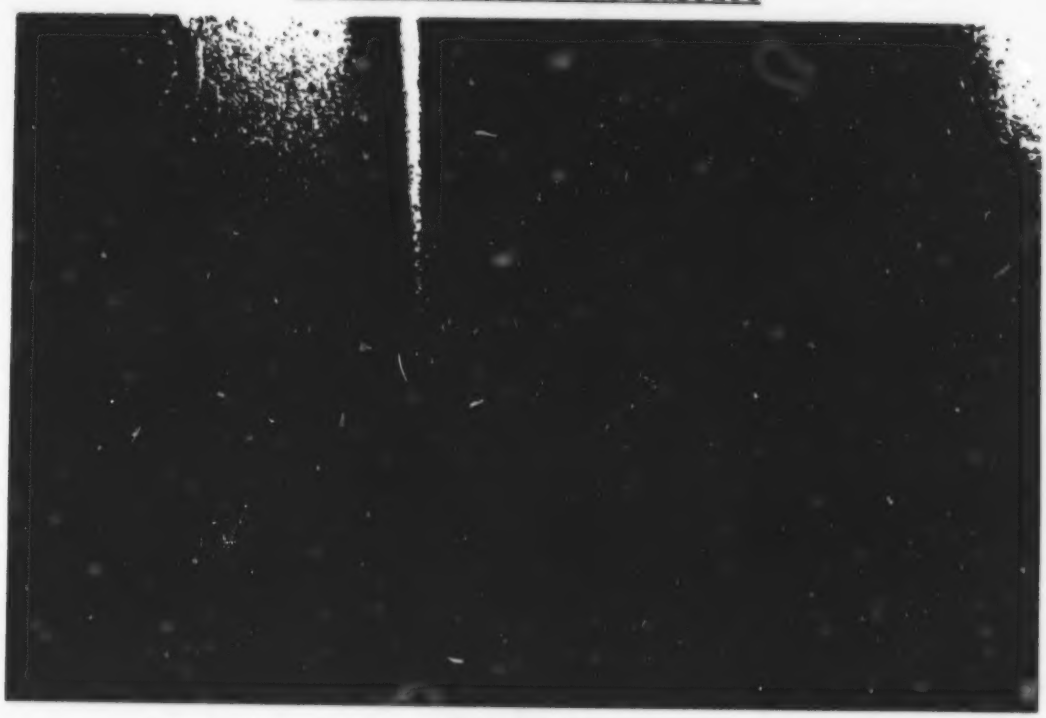

FIGURE 15

Small Cut in New Seal

FIGURE 16

Small Crack in New Seal

FIGURE 17

Small Crack in New Seal

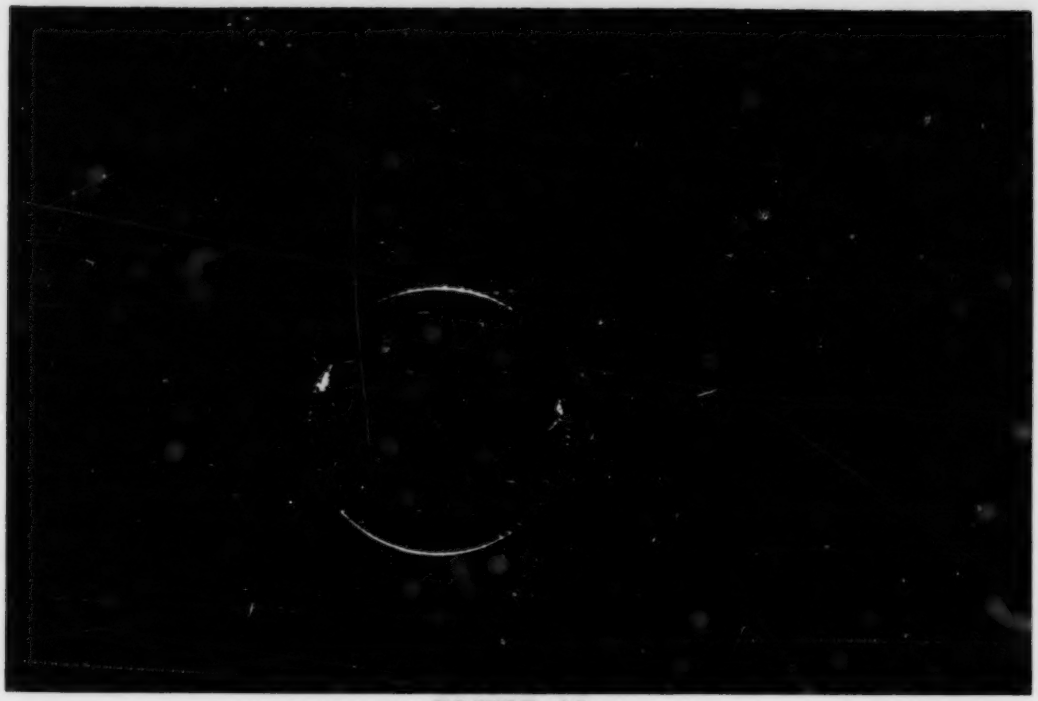

FIGURE 18

Small Wire in New Seal

FIGURE 19

Small Wire in New Seal

FIGURE 20

Small Wire in New Seal

FIGURE 21

Seal Supported by Two by Fours

FIGURE 22

Moving the Seal

FIGURE 23

Moving the Seal

FIGURE 24

Moving the Seal

FIGURE 25

Moving the Seal

FIGURE 26

Moving the Seal

FIGURE 27

Cleaning the Seal

FIGURE 28

Cleaning the Seal

FIGURE 29

Mounting the Seal-Aligning the Bolt Holes

FIGURE 30

Mounting the Seal-Fitting on Backup Plates

FIGURE 31

Mounting the Seal-Fitting on Backup Plates

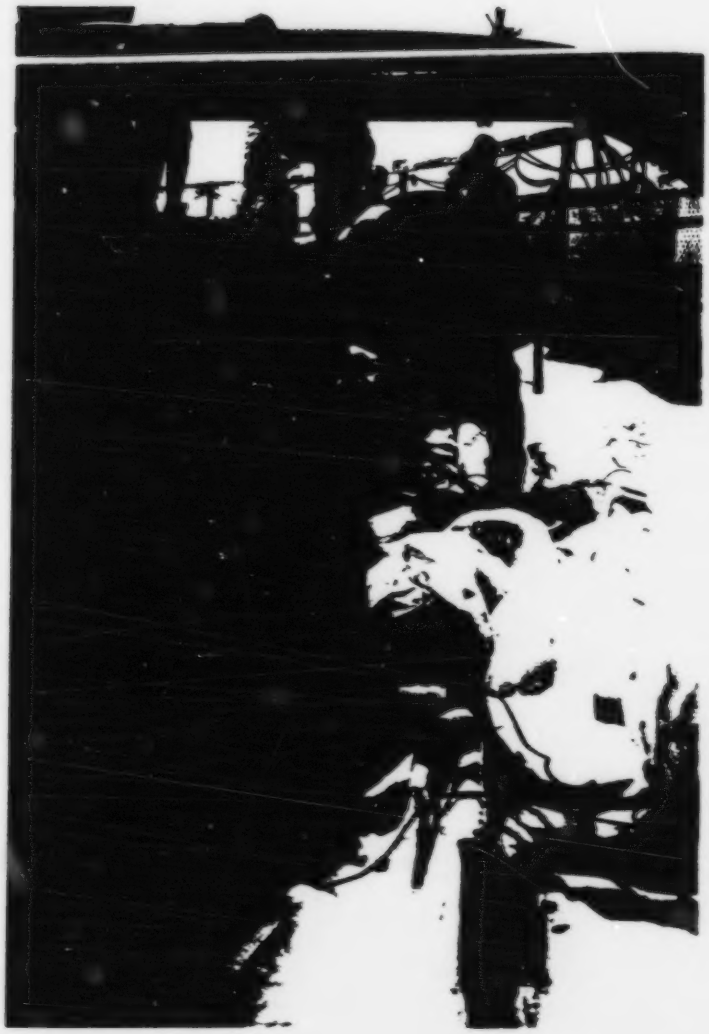

FIGURE 32

Mounting the Seal

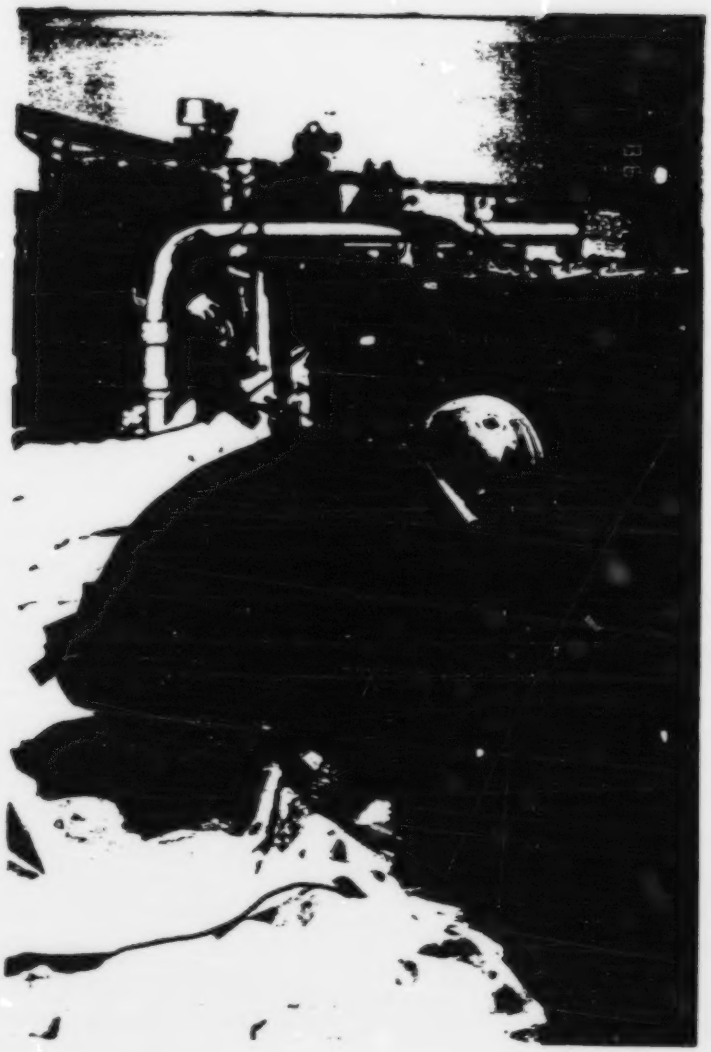

FIGURE 33

Mounting the Seal

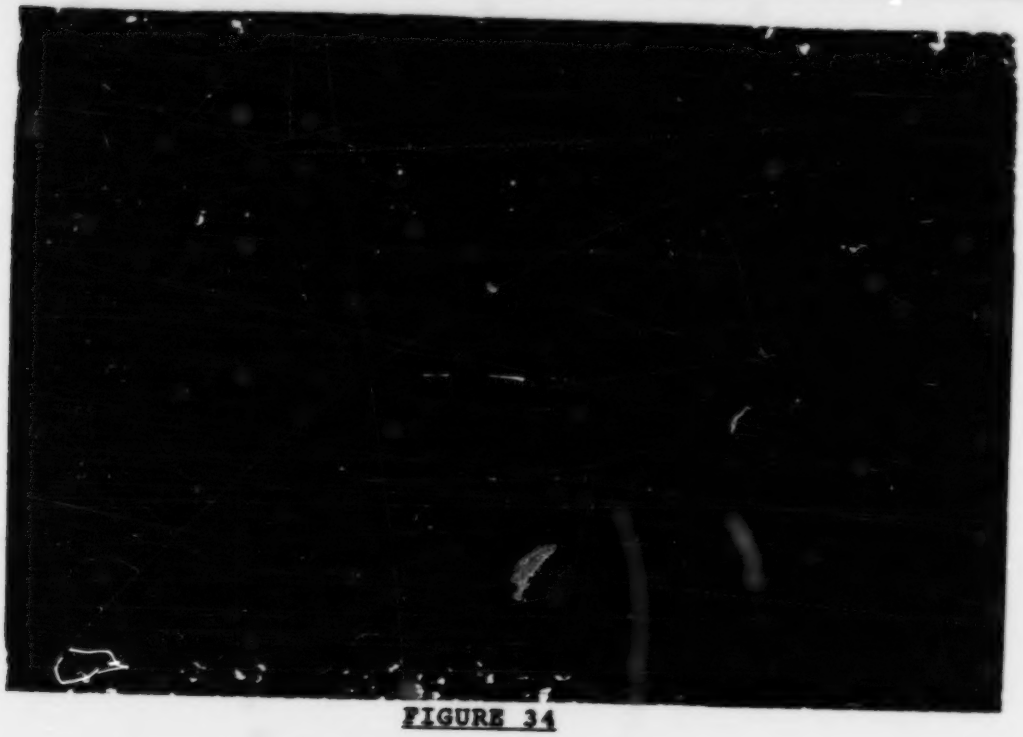

FIGURE 34

Edge View of Test Splice

FIGURE 35

Inside Surface of Test Splice

FIGURE 36

Outside Surface of Test Splice

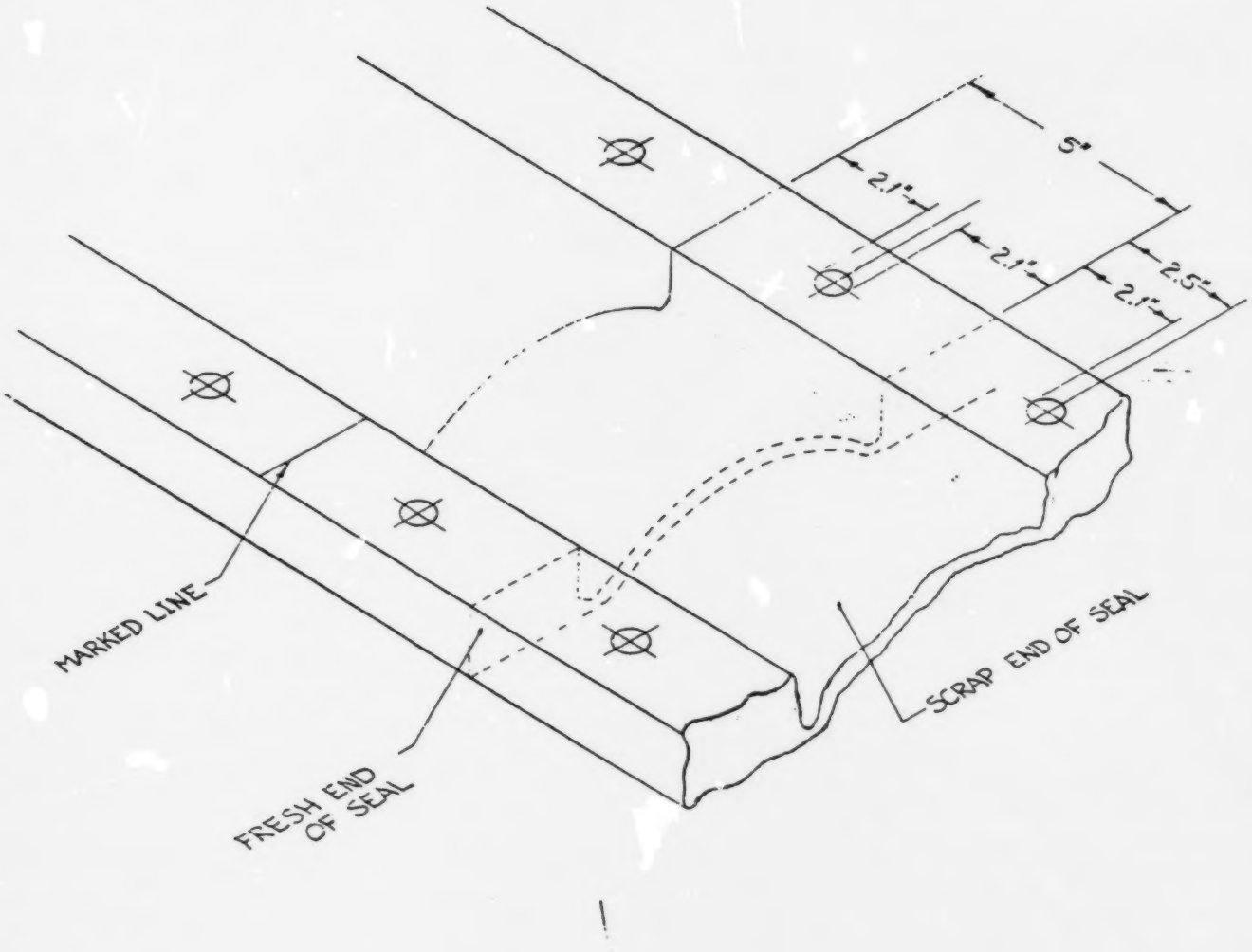

FIGURE 37

Preparation of Seal Before Splicing

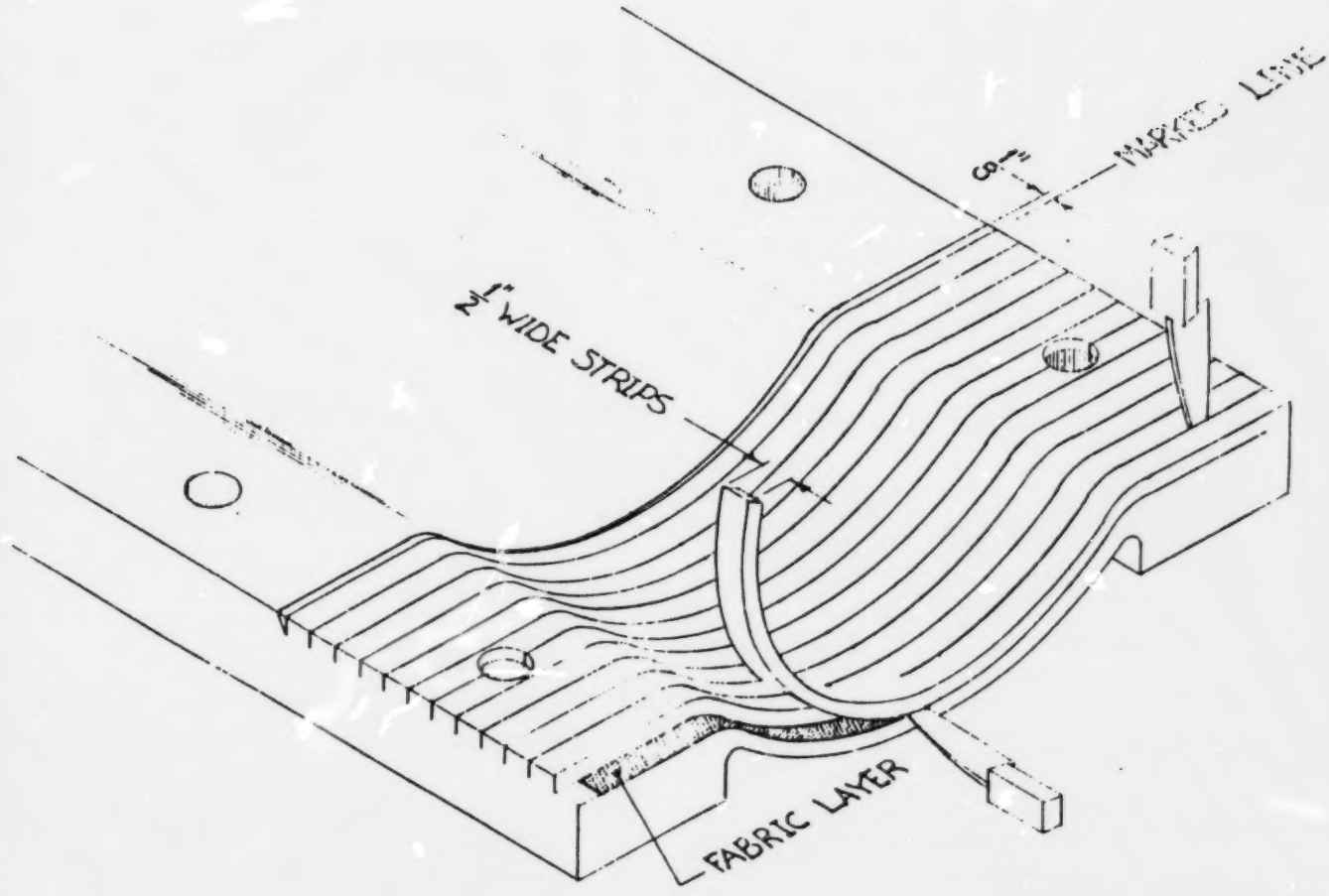

FIGURE 38

Outside Surface Splicing Preparation

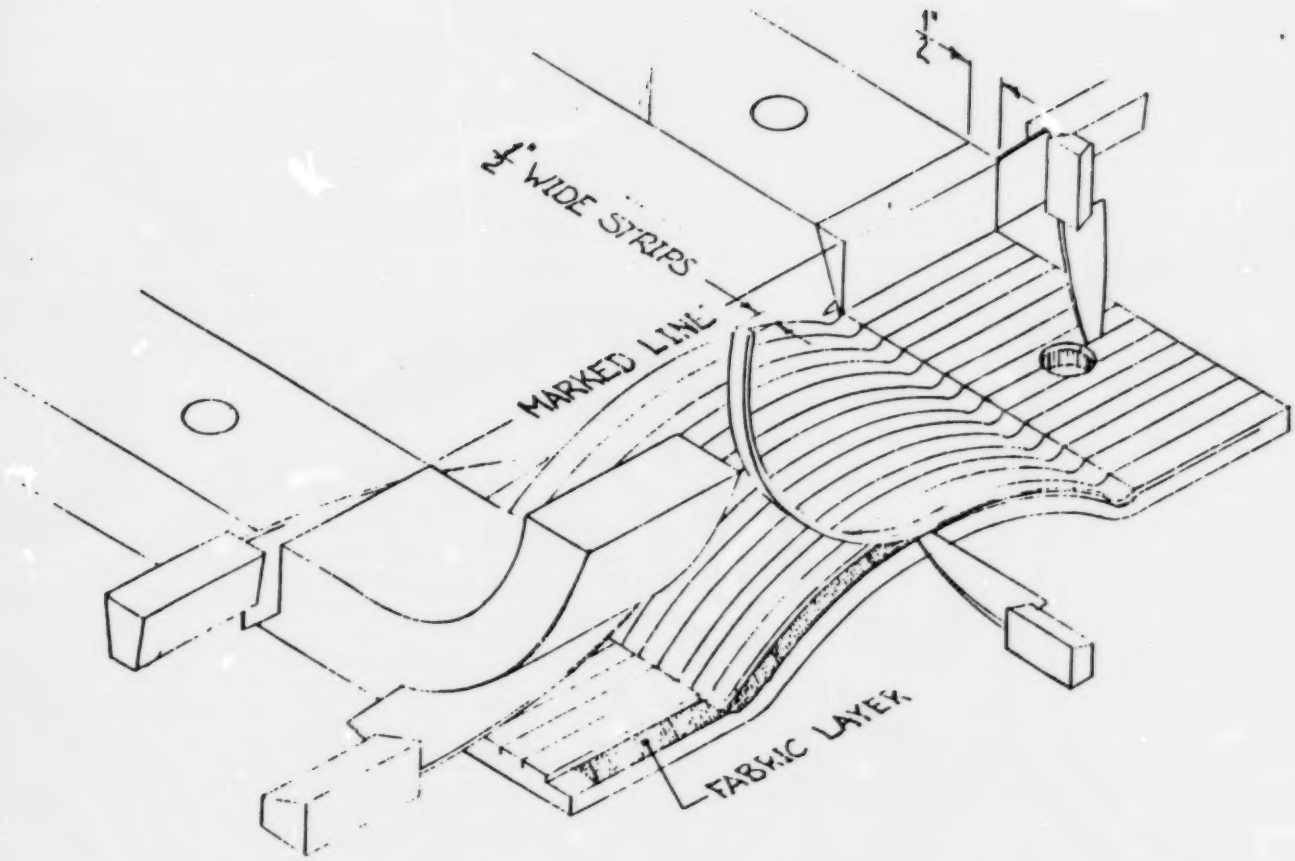

FIGURE 39

Inside Surface Splicing Preparation

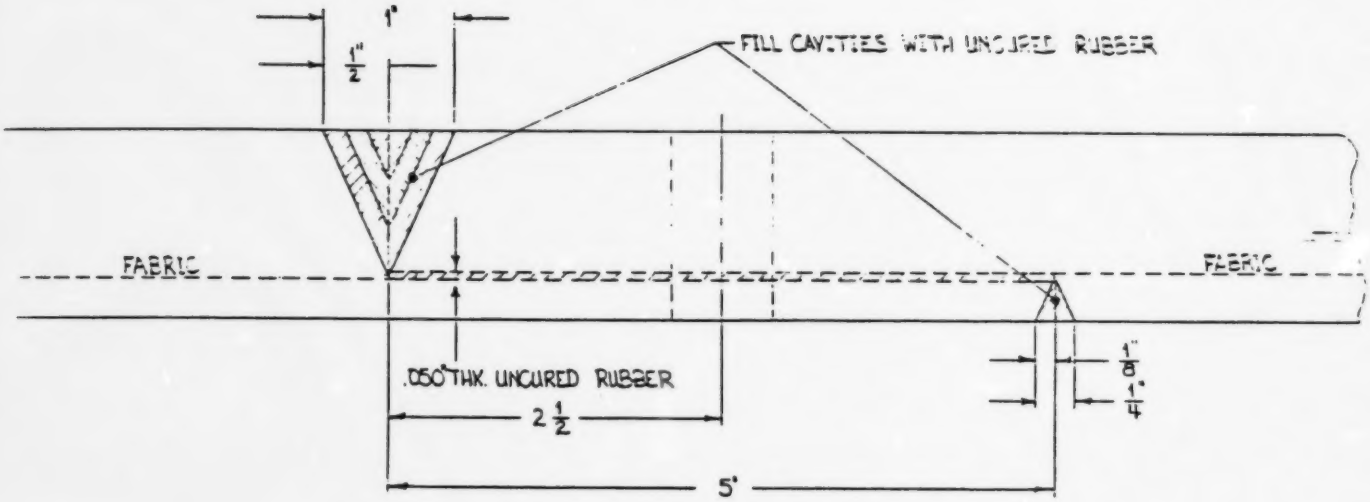

FIGURE 40

Side View of Seal Splice for Pickering NGS

FIGURE 41

Filling Gap in Outside Surface

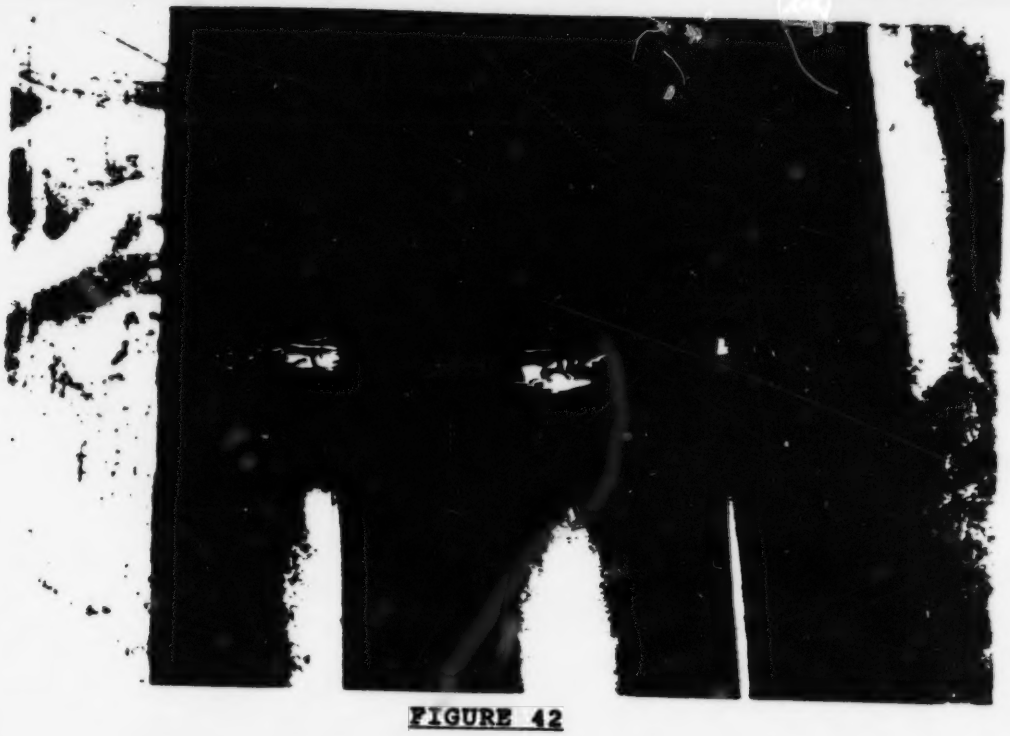

FIGURE 42

Splice - Outside Surfaces - Plugs in Holes

FIGURE 43

Splice - Inside Surface

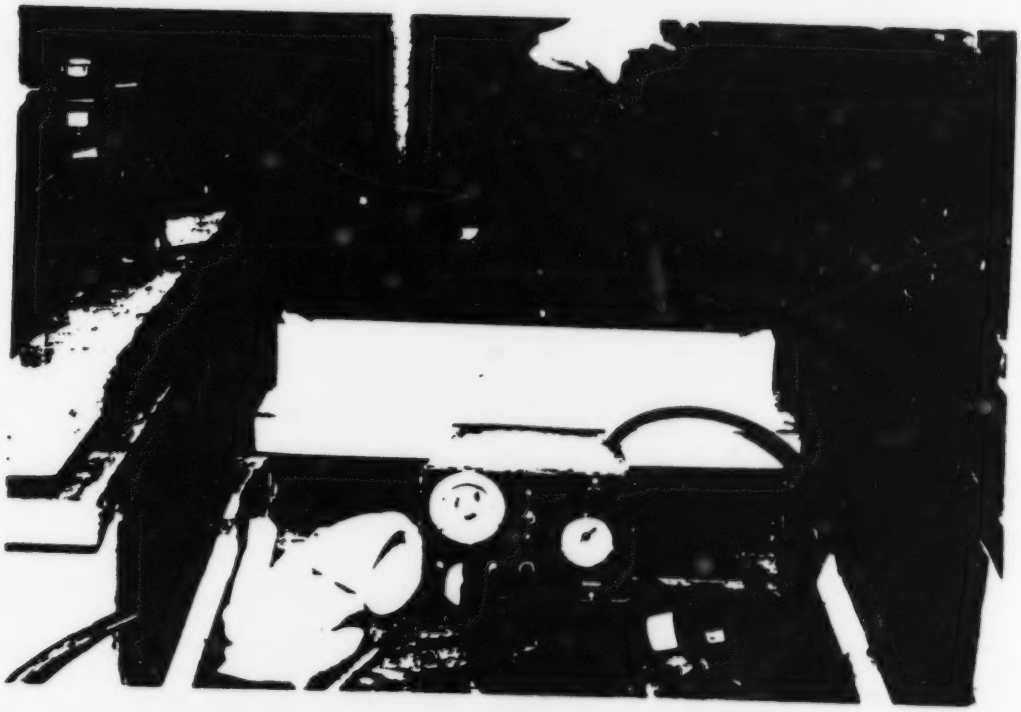

FIGURE 44

Splice in Press - Ends Clamped

FIGURE 45

Splicing - Filling Gap on Inside Surface

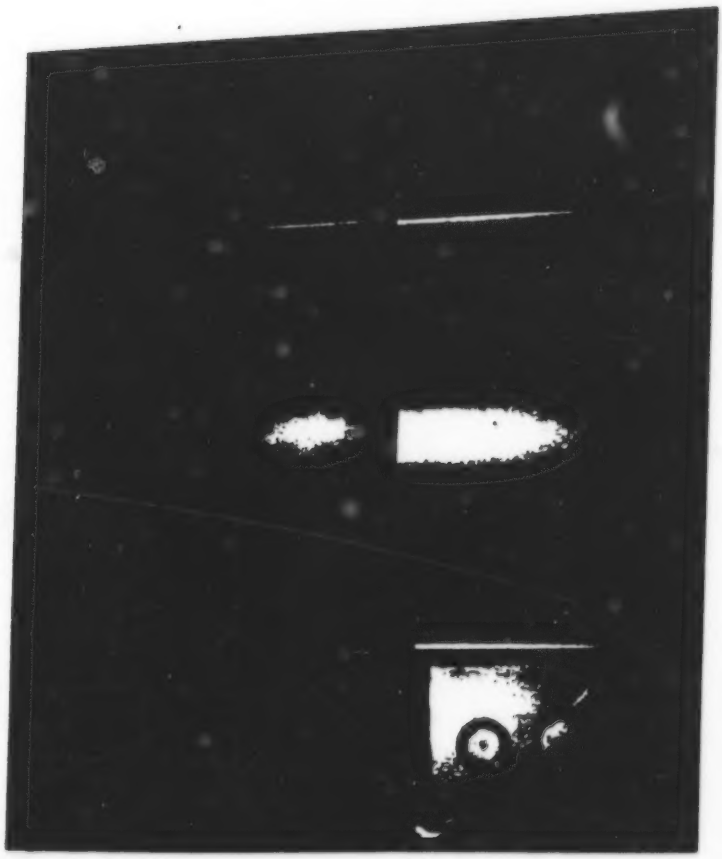

FIGURE 46

Gap on Inside Surface

FIGURE 47

Splicing - Filling Gap on Inside Surface

FIGURE 48

Splicing - Filling Gap on Inside Surface

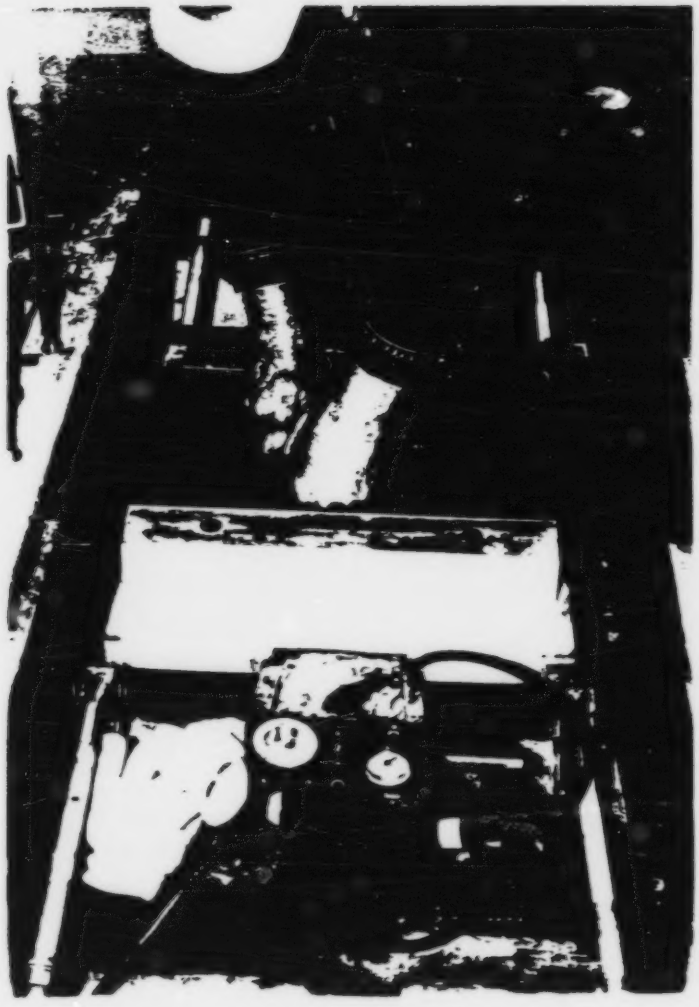

FIGURE 49

Splicing - Filling Gap on Inside Surface

FIGURE 50

Splicing - Filling Gap on Inside Surface

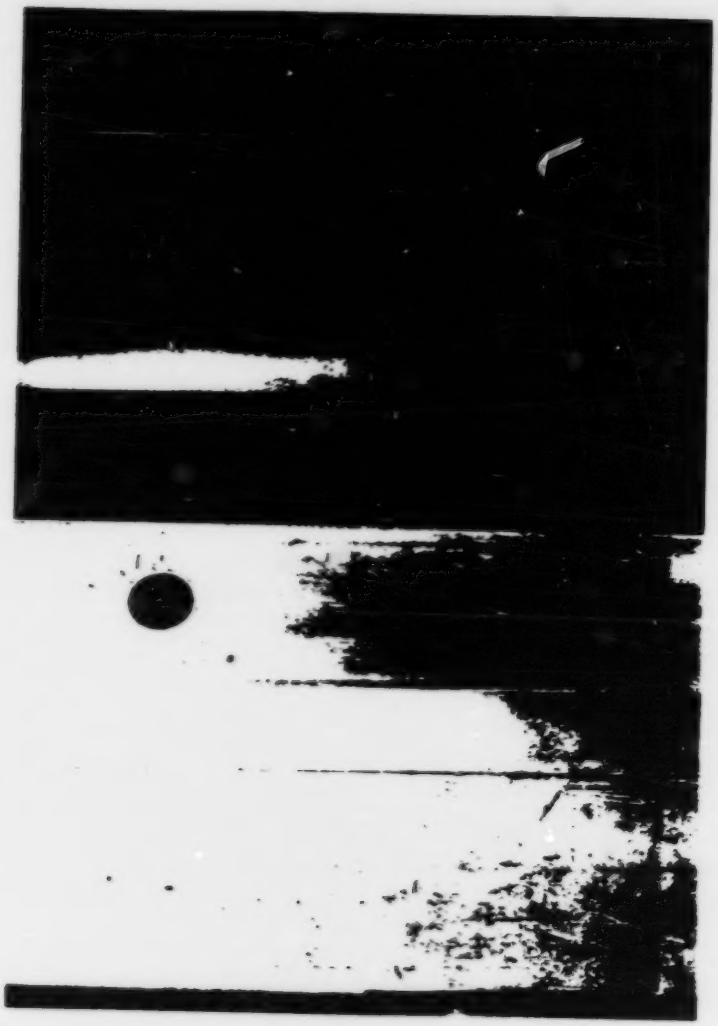

FIGURE 51

Splicing - Gap Filled on Inside Surface

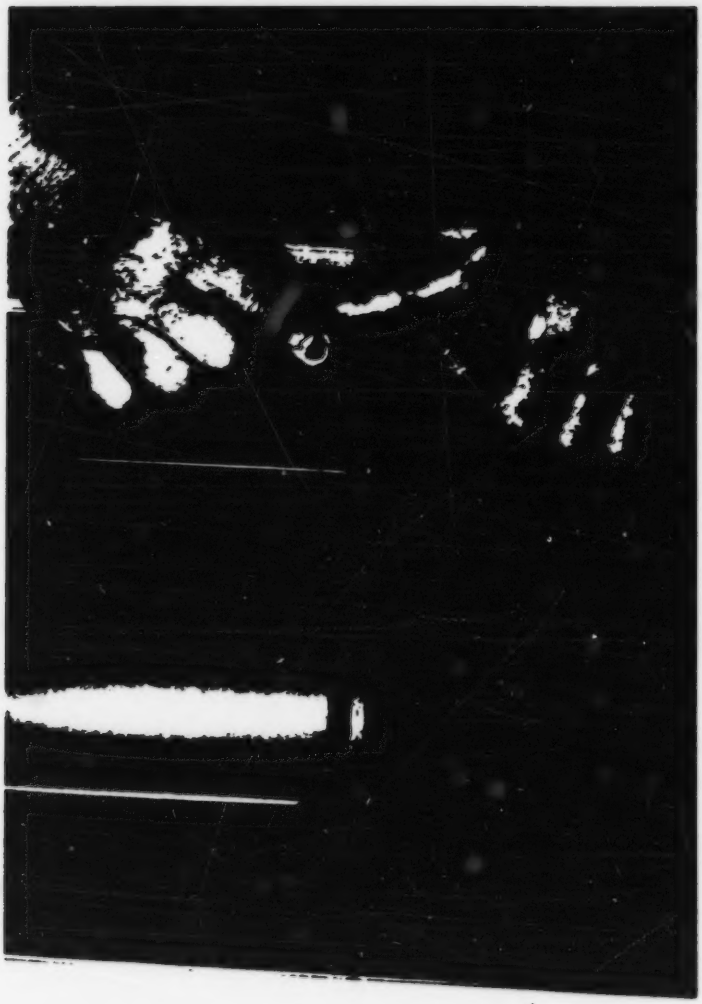

FIGURE 52

Splicing - Removing Excess Rubber from Gap on Inside Surface

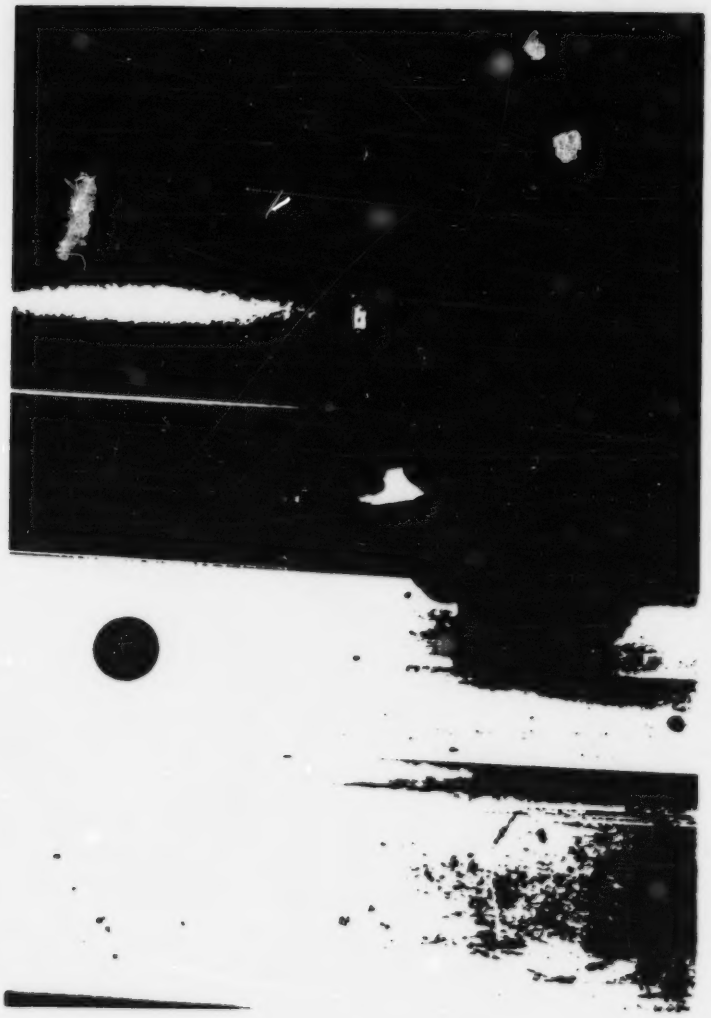

FIGURE 53

Splicing - Removing Excess Rubber from Gap on Inside Surface

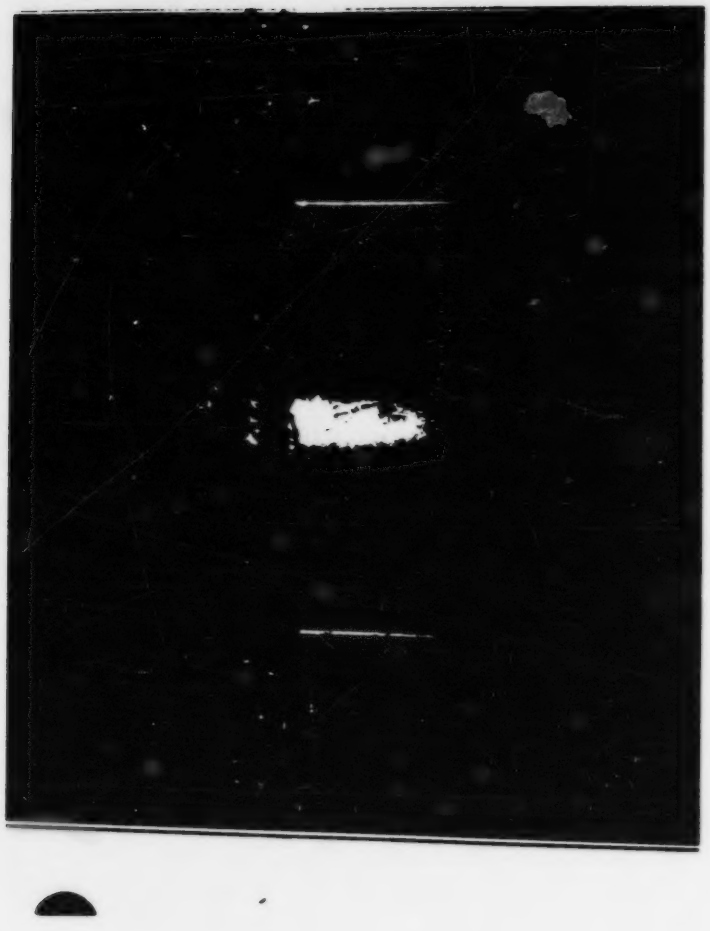

FIGURE 54

Splicing - Gap Filled on Inside Surface

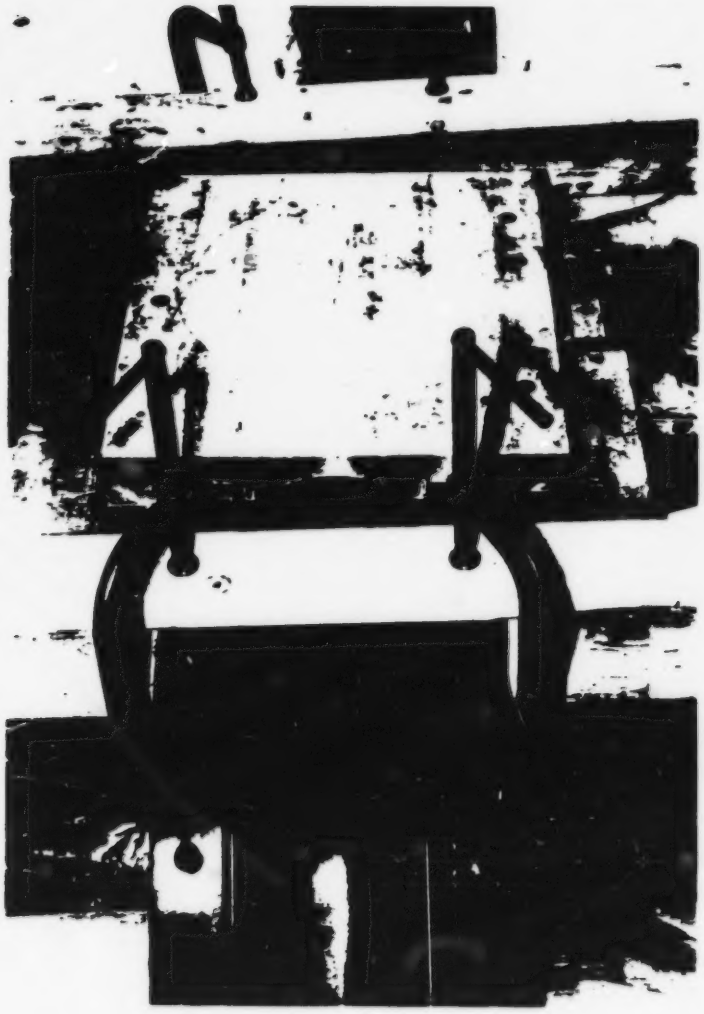

FIGURE 55

Top Half of Mould Fitted onto Seal

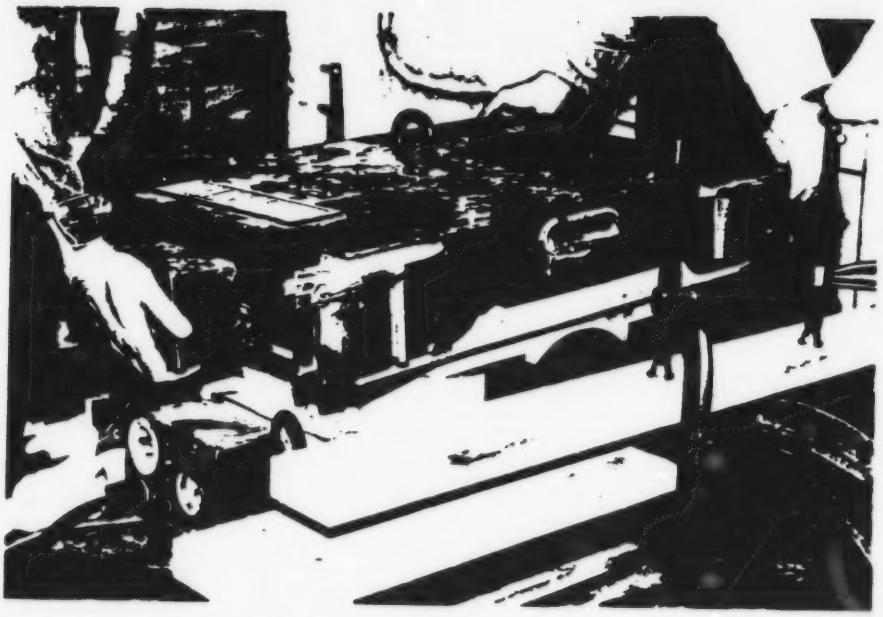

FIGURE 56

Top Half of Press Fitted onto Seal

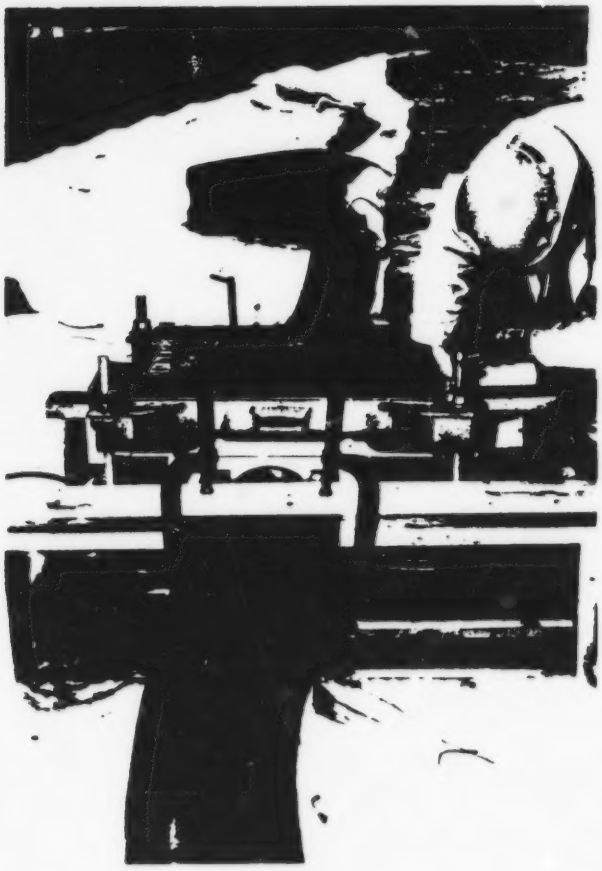

FIGURE 57

Tightening Bolds on Press

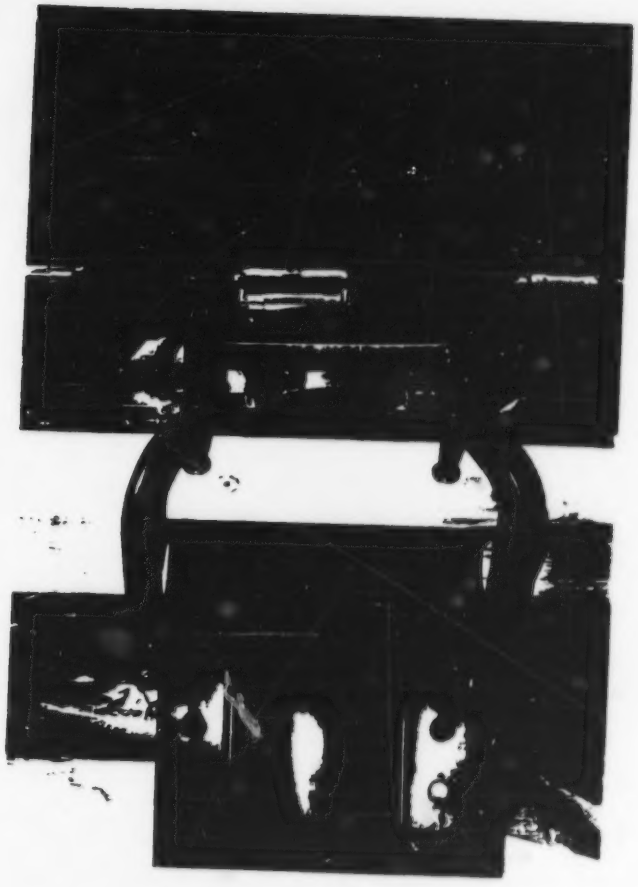

FIGURE 58

Seal in Press During Cure - West Side

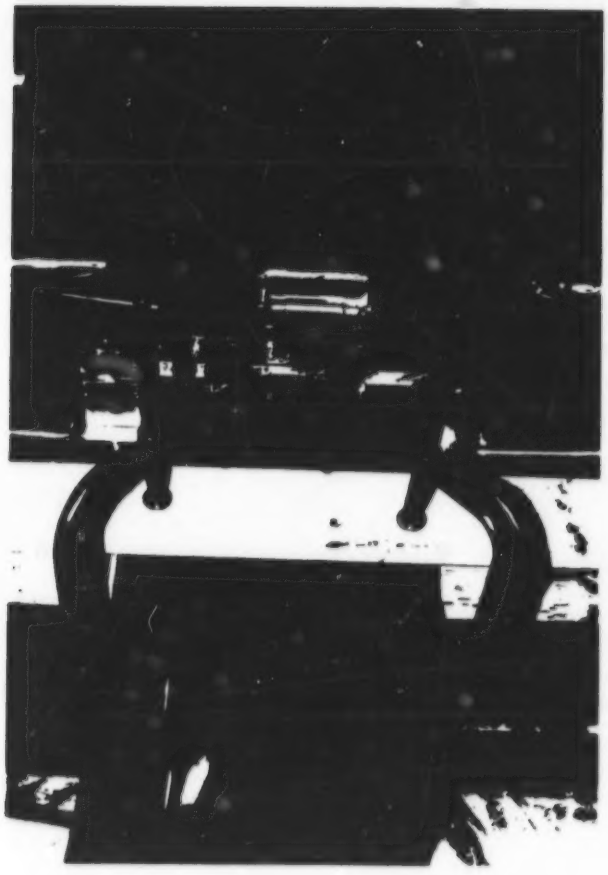

FIGURE 59

Seal in Press During Cure - East Side

FIGURE 60

Untightening Bolds on Press After Cure

FIGURE 61

Cured Splice After Press Removed

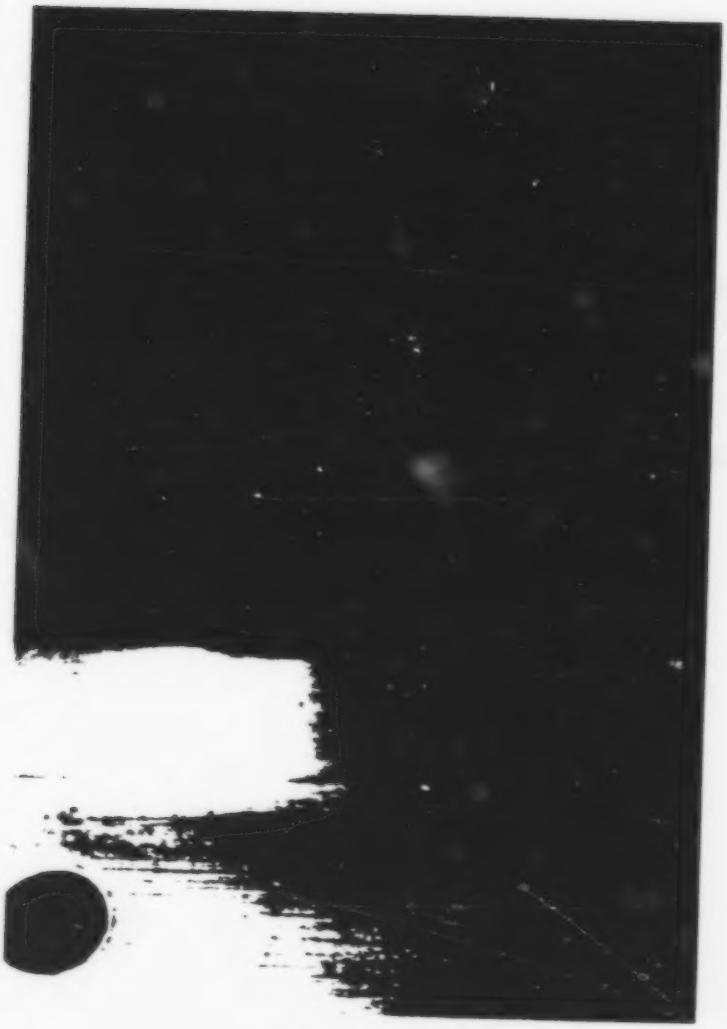

FIGURE 62

Finished Splice - Inside Surface

FIGURE 63

Finished Splice - Edge

FIGURE 64

Finished Splice - Outside Surface

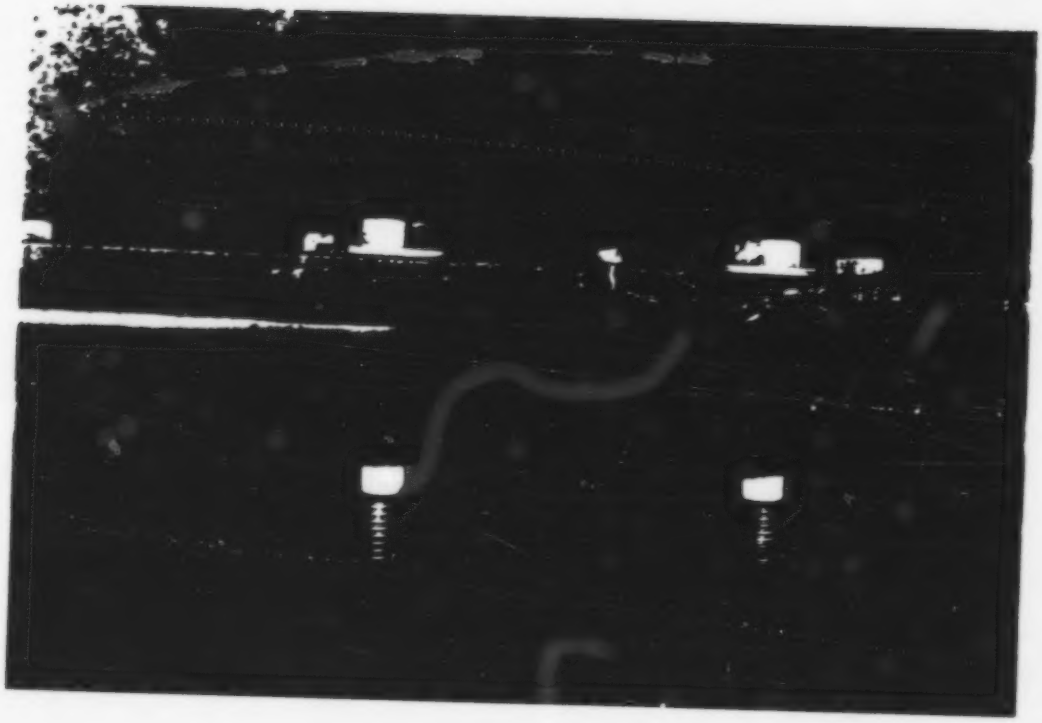

FIGURE 65

Edge of Seal Before Final Torque
of Bolts on Left After Final Torque on Right

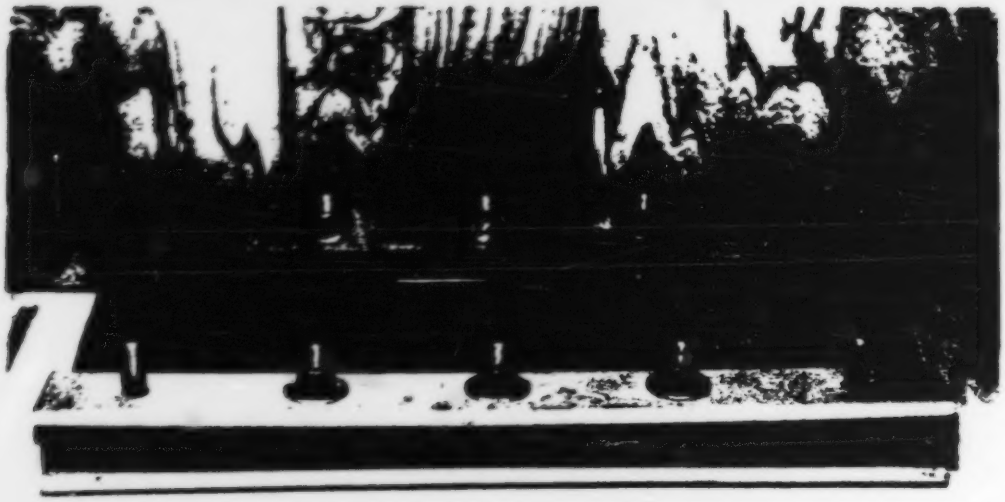

FIGURE 66

Roof Seal Outside Test Coupon

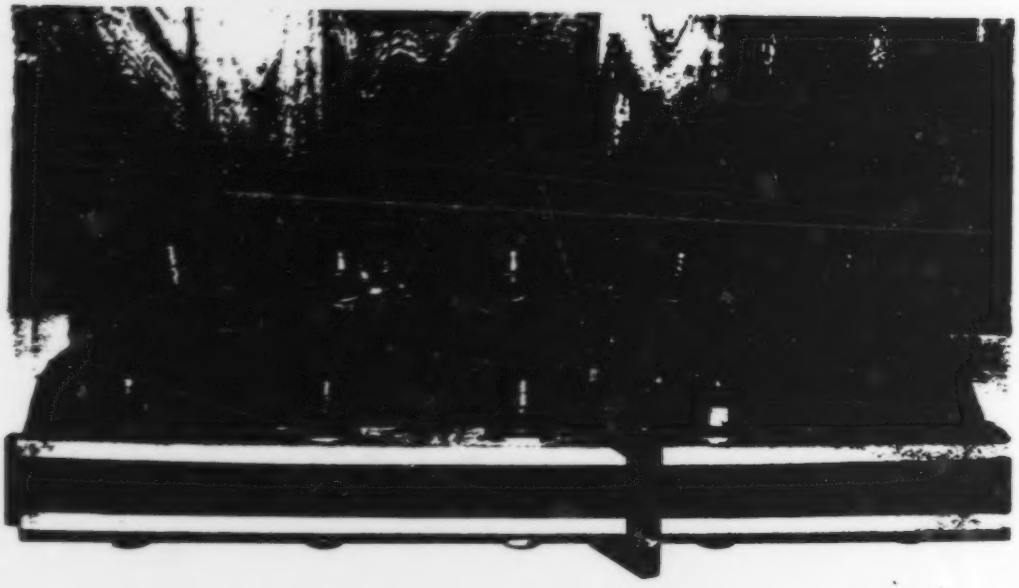

FIGURE 67

Roof Seal Inside Test Coupon